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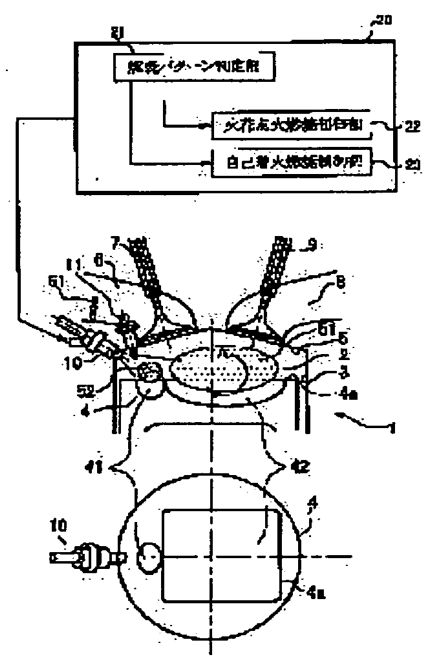
(54) CYLINDER DIRECT-INJECTION OF FUEL TYPE INTERNAL COMBUSTION ENGINE

(57)Abstract:

PROBLEM TO BE SOLVED: To enable a compressed self ignition combustion area to expand on the high-load side, by delaying ignition timing at the time of compressed self ignition combustion so as to slower the pace of increase in pressure within a cylinder.

SOLUTION: A fuel injection valve 10 is disposed to a cylinder wall on an intake port 6 side, a first recessed chamber 41 having a small opening area is formed in the fuel injection valve 10 side of a piston crown 4a, and a second recessed chamber 42 having a large opening area is formed near the first recessed chamber 41. Rich air-fuel mixture 52 is supplied in the first recessed chamber 41, and lean air-fuel mixture 51 is supplied in the second recessed chamber 42; and the rich air-fuel mixture 52 is burnt by spark ignition posterior to a top dead center to generate heat, and the heat causes the compressed self-ignition combustion of the lean air-fuel mixture 51.



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CLAIMS

[Claim(s)]
[Claim 1] The direct injection internal combustion engine in a cylinder characterized by forming the 2nd alcove which adjoins in the direction of an axis of said fuel injection valve to this 1st alcove while equipping the periphery of a combustion chamber with the fuel injection valve and forming the 1st alcove in the edge by the side of said fuel injection valve of a piston crestal plane.
[Claim 2] The direct injection internal combustion engine in a cylinder according to claim 1 with which opening area in the piston crestal plane of said 1st alcove is characterized by being smaller than the opening area of said 2nd alcove.
[Claim 3] The direct injection internal combustion engine in a cylinder according to claim 1 or 2 with which the depth of said 1st alcove is characterized by being shallower than the depth of said 2nd alcove.
[Claim 4] The direct injection internal combustion engine in a cylinder of any one publication of claim 1-3 characterized by being formed in the shape of [to which said 2nd alcove is circular in the cross section in the direction of an axis of a fuel injection valve, and opening spreads even in the periphery of a piston crestal plane] an abbreviation rectangle.
[Claim 5] The direct injection internal combustion engine in a cylinder of any one publication of claim 1-4 characterized by having a tumble flow strengthening means to strengthen the tumble flow formed in a cylinder like an inhalation-of-air line in a suction port.
[Claim 6] The direct injection internal combustion engine in a cylinder according to claim 5 characterized by strengthening the tumble flow which said tumble flow strengthening means is the latching valve which opens and closes a suction port partially, and inhalation of air is made to produce channeling by closing this latching valve, and is formed in a cylinder like an inhalation-of-air line.
[Claim 7] The direct injection internal combustion engine in a cylinder of any one publication of claim 1-6 characterized by allotting rich gaseous mixture to said 1st alcove, and allotting Lean gaseous mixture to said 2nd alcove.
[Claim 8] The direct injection internal combustion engine in a cylinder according to claim 7 which is the gaseous mixture to which the rich gaseous mixture allotted to said 1st alcove results in compressed self-ignition [near the top dead center], and is characterized by making the Lean gaseous mixture allotted to said 2nd alcove result in compressed self-ignition combustion by the compressed self-ignition of the rich gaseous mixture allotted to this 1st alcove.
[Claim 9] The direct injection internal combustion engine in a cylinder according to claim 7 characterized by making the Lean gaseous mixture allotted to said 2nd alcove by lighting the rich gaseous mixture allotted to said 1st alcove by jump spark ignition of an ignition plug result in compressed self-ignition combustion.
[Claim 10] The direct injection internal combustion engine in a cylinder of any one publication of claim 7-9 characterized by allotting rich gaseous mixture to said 1st alcove, and allotting Lean gaseous mixture to said 2nd alcove by making a fuel inject from said fuel injection valve in a compression stroke.
[Claim 11] allotting rich gaseous mixture to said 1st alcove, and allotting Lean gaseous mixture to said 2nd alcove [in the same cycle], by making a fuel inject in at least 2 steps of fuel injection [/ near the top dead center], and the fuel injection before this fuel injection timing from the second half

of a compression stroke, -- the direct injection internal combustion engine in a cylinder of any one publication of claim 7-9 characterized by things.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the engine which makes compressed self-ignition combustion perform especially using a fuel with the low cetane number like a gasoline about the direct injection internal combustion engine in a cylinder.
[0002]
[Description of the Prior Art] Conventionally, there were some which are indicated by JP,10-196424,A as an internal combustion engine which performs compressed self-ignition combustion. applying compression by said control piston further to the gaseous mixture which this thing was equipped with the control piston as an auxiliary compression means apart from the piston in a cylinder, and was compressed even into the elevated temperature in front of self-ignition -- it is -- the above -- it has composition to which self-ignition of the gaseous mixture is carried out all at once.
[0003] Moreover, the engine constituted so that jump spark ignition by the ignition plug might cause self-ignition is indicated by JP,11-210539,A. the gas temperature in the cylinder in the compression stroke last stage lights this thing -- gaseous mixture -- he is trying to maintain the gas temperature in the cylinder in the compression stroke last stage to the above-mentioned target temperature by judging whether it is the target temperature which causes the whole self-ignition, and controlling the valve-opening stage of an inlet valve based on this decision
[0004]
[Problem(s) to be Solved by the Invention] by the way, unlike combustion by flame propagation, compressed self-ignition combustion has the advantage that a local combustion temperature is low and NOx occurs only in ultralow volume -- on the other hand, homogeneous gaseous mixture -- at a place, in order that the whole region in a cylinder may light all at once, when gaseous mixture is made rich with a rise of a load, there is a problem that the rate of a pressure buildup in a cylinder becomes large too much, and vibration and the noise become large.
[0005] Therefore, in order to expand the load field to which compressed self-ignition combustion operation is made to perform to a heavy load side, it is necessary to set up an ignition stage near a top dead center or after it, and to control the rate of a pressure buildup in a cylinder by making the period after a top dead center produce a great portion of combustion. However, when an ignition stage is delayed near a top dead center or after it, in order that early combustion may progress with descent of a piston, combustion tends to become unstable, in order to expand the load field to which compressed self-ignition combustion operation is made to perform to a heavy load side, the stage of ignition is delayed, and the stable flammability needs to be made to be obtained.
[0006] gaseous mixture homogeneous on the other hand -- at a place, if the assistance by ignition plug which is indicated by JP,11-210539,A is applied, the ignition stage of compressed self-ignition combustion can be stabilized. However, by the above-mentioned approach, though compressed self-ignition combustion occurs near a top dead center or after it, an ignition stage cannot be delayed and effectiveness is not demonstrated for expansion by the side of the heavy load of a compressed self-ignition combustion zone.
[0007] moreover, compressed self-ignition combustion -- setting -- local -- rich gaseous mixture -- a place -- forming -- the self-ignition from there -- or spark ignition is carried out -- making -- rich gaseous mixture -- the approach of carrying out compressed self-ignition of the surrounding fuel by

combustion from a place is indicated by JP,11-210539,A. However, a fuel is injected towards a piston crestal plane from the peripheral wall of the side by which the inlet valve of a combustion chamber is arranged so that it may be indicated by JP,11-210539,A. With the configuration which raises the fuel spray along with the wall surface prepared in the piston crestal plane, and is brought together in the circumference of an ignition plug rich -- ignition PURAGUHE which it was difficult to stop gaseous mixture in a fixed location, and it allotted focusing on the cylinder head, in order to supply rich gaseous mixture adequately Since rich gaseous mixture exists mostly even if it is necessary to inject many fuels and is able to delay an ignition stage near a top dead center or after it, it is difficult to lower the rate of a pressure buildup.

[0008] this invention is made in view of the above-mentioned trouble -- having -- rich gaseous mixture -- carrying out compressed self-ignition of the surrounding fuel by combustion from a place -- certain -- the rate of a pressure buildup -- it can control -- with -- **** -- it aims at offering the direct injection internal combustion engine in a cylinder which becomes possible [expanding a compressed self-ignition combustion zone to a heavy load side].

[0009]

[Means for Solving the Problem] Therefore, in invention according to claim 1, while equipping the periphery of a combustion chamber with the fuel injection valve and forming the 1st alcove in the edge by the side of said fuel injection valve of a piston crestal plane, it considered as the configuration which forms the 2nd alcove which adjoins in the direction of an axis of said fuel injection valve to this 1st alcove.

[0010] According to this configuration, it becomes possible to form the 1st alcove and the 2nd alcove on a piston crestal plane, and to form the gaseous mixture of concentration (air-fuel ratio) different, respectively in these 1st alcoves and the 2nd alcove along the direction of an axis of a fuel injection valve. In invention according to claim 2, opening area in the piston crestal plane of said 1st alcove was considered as the configuration made smaller than the opening area of said 2nd alcove.

[0011] according to this configuration -- the opening area of the 2nd alcove of a side with an opening area of the 1st alcove of the side near a fuel injection valve far from a fuel injection valve -- narrow -- the 1st alcove -- local gaseous mixture -- while a place is formed, stratification-ization of the gaseous mixture from which concentration differs by the combustion chamber is performed by allotting the gaseous mixture from which concentration differs to the 2nd alcove where opening area is large. In invention according to claim 3, the depth of said 1st alcove was considered as the configuration made shallower than the depth of said 2nd alcove.

[0012] according to this configuration -- the opening area of the 2nd alcove of a side with the depth of the 1st alcove of the side near a fuel injection valve far from a fuel injection valve -- shallow -- the 1st alcove -- local gaseous mixture -- while a place is formed, stratification-ization of the gaseous mixture from which concentration differs by the combustion chamber is performed by allotting the gaseous mixture from which concentration differs to the 2nd deep alcove. In invention according to claim 4, it considered as the configuration formed in the shape of [to which said 2nd alcove is circular in the cross section in the direction of an axis of a fuel injection valve, and opening spreads even in the periphery of a piston crestal plane] an abbreviation rectangle.

[0013] According to this configuration, the tumble flow by the inhalation of air in a cylinder is held by being formed in the shape of [to which the base of the 2nd alcove is circular in the cross section in the direction of an axis of a fuel injection valve, and ** also spreads even in the periphery of a piston crestal plane] an abbreviation rectangle. It considered as the configuration equipped with a tumble flow strengthening means to strengthen with invention according to claim 5 the tumble flow formed in a cylinder like an inhalation-of-air line in a suction port.

[0014] According to this configuration, the tumble flow formed of inhalation of air in a cylinder by the tumble flow strengthening means is strengthened positively. In invention according to claim 6, it was the latching valve which opens and closes a suction port partially, and said tumble flow strengthening means made inhalation of air produce channeling by closing this latching valve, and considered as the configuration which strengthens the tumble flow formed in a cylinder like an inhalation-of-air line.

[0015] According to this configuration, channeling of inhalation of air arises so that a tumble flow may be strengthened with a part of suction port being covered by the latching valve. In invention

according to claim 7, it considered as the configuration which allots rich gaseous mixture to said 1st alcove, and allots Lean gaseous mixture to said 2nd alcove. Lean gaseous mixture is allotted to the 2nd alcove contiguous to this 1st alcove, and rich according to this configuration, while rich gaseous mixture is allotted to the 1st alcove -- rich in the Lean gaseous mixture which adjoins because gaseous mixture burns by jump spark ignition or compressed self-ignition -- it is possible for you to make it result in self-ignition combustion in generation of heat of gaseous mixture.
[0016] In invention according to claim 8, it is the gaseous mixture to which the rich gaseous mixture allotted to said 1st alcove results in compressed self-ignition [near the top dead center], and considered as the configuration in which the Lean gaseous mixture allotted to said 2nd alcove is made to result in compressed self-ignition combustion by the compressed self-ignition of the rich gaseous mixture allotted to this 1st alcove. If the rich gaseous mixture which was allotted to the 1st alcove according to this configuration results in compressed self-ignition, the Lean gaseous mixture allotted to the 2nd alcove which adjoins by the generation of heat will result in compressed self-ignition combustion.
[0017] In invention according to claim 9, it considered as the configuration in which the Lean gaseous mixture allotted to said 2nd alcove is made to result in compressed self-ignition combustion by lighting the rich gaseous mixture allotted to said 1st alcove by jump spark ignition of an ignition plug. If jump spark ignition of the rich gaseous mixture which was allotted to the 1st alcove according to this configuration is carried out with an ignition plug, the Lean gaseous mixture allotted to the 2nd alcove which adjoins by the generation of heat will result in compressed self-ignition combustion.
[0018] In invention according to claim 10, it considered as the configuration which allots rich gaseous mixture to said 1st alcove, and allots Lean gaseous mixture to said 2nd alcove by making a fuel inject from said fuel injection valve in a compression stroke. According to this configuration, Lean [the 2nd alcove which collision diffusion is carried out, and the base of the 1st alcove is covered with rich gaseous mixture in the 1st alcove, and adjoins] fuel spray gaseous mixture is formed by injecting a fuel in a compression stroke.
[0019] In invention according to claim 11, it considered as the configuration which allots rich gaseous mixture to said 1st alcove, and allots Lean gaseous mixture to said 2nd alcove by making a fuel inject in at least 2 steps of fuel injection [/ near the top dead center], and the fuel injection before this fuel injection timing from the second half of a compression stroke [in the same cycle]. according to this configuration, the fuel injected [near the top dead center] from the second half of a compression stroke stops [the 1st concave interior of a room] and is rich -- the fuel injected in the stage before fuel injection timing [/ near the top dead center] from this second half of a compression stroke while forming gaseous mixture -- diffusion -- the 2nd alcove -- Lean -- gaseous mixture is formed.
[0020]
[Effect of the Invention] gaseous mixture possible [according to invention according to claim 1 allotting the gaseous mixture of concentration (air-fuel ratio) which is different in the 1st alcove and the 2nd alcove, and stratification-izing gaseous mixture stably], and rich -- in the configuration to which compressed self-ignition of the Lean gaseous mixture which adjoins by combustion from a place is carried out, only necessary minimum can make rich gaseous mixture able to generate, it can be made to light, and it is effective in the ability to be able to delay combustion of most fuels now.
[0021] according to invention of claim 2 and three publications -- the 1st alcove -- local gaseous mixture -- it considers as forming space and is effective in the ability to stratification-ize certainly gaseous mixture from which concentration differs. According to invention according to claim 4, the tumble flow by inhalation of air is held by the 2nd alcove, the gaseous mixture generated by the 2nd alcove can be equalized, and it is effective in the ability to raise combustion stability.
[0022] According to invention of claim 5 and six publications, the gaseous mixture generated by the 2nd alcove can be equalized by strengthening the tumble flow generated by inhalation of air, and it is effective in the ability to raise combustion stability. according to invention according to claim 7, it is stably allotted to the 1st alcove -- local -- rich -- compressed self-ignition of the Lean gaseous mixture allotted to the 2nd alcove can be carried out by combustion of gaseous mixture, and necessary minimum is rich -- it becomes possible by combustion of gaseous mixture to make most

fuels result in compressed self-ignition combustion, and it is effective in the ability to expand now a compressed self-ignition combustion zone to a heavy load side because combustion of most fuels is overdue.
[0023] Since the Lean gaseous mixture allotted to the 2nd alcove which adjoins by compressed self-ignition combustion of the rich gaseous mixture allotted to the 1st alcove is made to result in compressed self-ignition combustion according to invention according to claim 8, a great portion of combustion is generated near a top dead center or after it, the rate of a pressure buildup can be controlled, and it is effective in the ability to expand now a compressed self-ignition combustion zone to a heavy load side.
[0024] Since the Lean gaseous mixture allotted to the 2nd alcove which adjoins by jump-spark-ignition combustion of the rich gaseous mixture allotted to the 1st alcove is made to result in compressed self-ignition combustion according to invention according to claim 9 While being able to generate a great portion of combustion near a top dead center or after it, being able to control the rate of a pressure buildup and being able to expand a compressed self-ignition combustion zone to a heavy load side Since jump-spark-ignition combustion of the rich gaseous mixture allotted to the 1st alcove is carried out, it is effective in being controllable within limits which can control the rate of a pressure buildup for a self-ignition stage, and can secure combustion stability.
[0025] According to invention according to claim 10, it is effective in the ability to perform easily allotting rich gaseous mixture to the 1st alcove and allotting Lean gaseous mixture to the 2nd alcove by injection in a compression stroke. stably rich [to the 1st alcove] by considering as the configuration which injects a fuel in 2 steps or more within the same cycle, and making the fuel injection of the 2nd henceforth perform [near the top dead center] from the second half of a compression stroke according to invention according to claim 11 -- it is effective in the ability to form gaseous mixture.
[0026]
[Embodiment of the Invention] The gestalt of operation of this invention is explained based on drawing below. Drawing 1 shows the gasoline engine of the direct injection in a cylinder with which this invention is applied. In this drawing 1 , an engine's 1 combustion chamber 2 is formed of a cylinder 3, a piston 4, and the cylinder head 5.
[0027] An intake valve 7 is infixed in the suction port 6 which is open for free passage to said combustion chamber 2, and the exhaust air bulb 9 is infixed in the exhaust air port 8 which is similarly open for free passage to a combustion chamber 2. Said cylinder head 5 is formed in a PENTO roof mold, and said intake valve 7 and the exhaust air bulb 9 are arranged at a V type. The fuel injection valve 10 which injects a fuel towards piston crestal plane 4a is formed in the cylinder wall by the side of said suction port 6, and an ignition plug 11 is formed in it that jump spark ignition of the gaseous mixture of fuel injection valve 10 directly under should be carried out to the this about ten fuel injection valve cylinder head 5.
[0028] The 1st alcove 41 and the 2nd alcove 42 are formed in the crestal plane of said piston 4. Said 1st alcove 41 is formed so that a base may become deep in a core, while being formed in the edge by the side of the fuel injection valve 10 of a piston crestal plane and making opening into a short ellipse form at the shaft orientations of a fuel injection valve 10. in addition, gaseous mixture with an opening area of said 1st alcove 41 local to about 11 ignition plug -- compared with the opening area of the 2nd alcove 42, it is formed small sharply that a place should be formed.
[0029] Moreover, the 2nd alcove 42 is adjoined and formed in the direction of an axis of a fuel injection valve 10 to said 1st alcove 41, from the side near a fuel injection valve 10, is located in a line in order of the 1st alcove 41 and the 2nd alcove 42, and is formed. Opening of said 2nd alcove 42 has the shape of a rectangle which consists of the side of the pair which intersects perpendicularly the sides and these sides of the pair prolonged along the direction of an axis of a fuel injection valve 10, and it is formed so that it may spread even in the periphery of a piston crestal plane. And as elliptical opening of said 1st alcove 41 touches one side by the side of the fuel injection valve 10 of opening of the shape of said rectangle, the 1st alcove 41 and the 2nd alcove 42 adjoin it.
[0030] Moreover, the base of said 2nd alcove 42 is formed so that it may become radii-like in the cross section of the direction of an axis of a fuel injection valve 10, and the maximum depth is formed so that it may become deeper than said 1st alcove 41. The engine control unit (henceforth

ECU) 20 which controls the injection quantity and fuel injection timing by said fuel injection valve 10, and the ignition timing by the ignition plug 11 By which combustion system of compressed self-ignition combustion and jump-spark-ignition combustion, operation By the combustion pattern judging section 21 which judges whether it carries out according to a service condition, the jump-spark-ignition combustion control section 22 which controls said fuel injection valve 10 and ignition plug 11 at the time of jump-spark-ignition combustion, and the self-ignition combustion control section 23 which controls said fuel injection valve 10 and ignition plug 11 at the time of compressed self-ignition combustion It is constituted.

[0031] As shown in drawing 2 , said combustion pattern judging section 21 is a configuration which distinguishes a combustion system based on an engine's load and rotational frequency N (rpm), judges a low Naka load and a low middle turn field as a compressed self-ignition combustion zone, and judges the other heavy load and quantity rotation field to be a jump-spark-ignition combustion zone. In addition, although said combustion pattern judging section 21, the jump-spark-ignition combustion control section 22, and the self-ignition combustion control section 23 can be constituted from a hard-wired logical circuit, they are realized as a program of a microcomputer with this operation gestalt.

[0032] The flow chart of drawing 3 shows the situation of the fuel-injection control by said ECU20, and reads an engine's 1 load and rotational frequency at step S101. At step S102, it distinguishes whether it is a low loading field in the compressed self-ignition combustion zone shown in drawing 2 . And when it is a low loading field in a compressed self-ignition combustion zone, progress to step S103, fuel injection is made to perform in the second half from the first half of a compression stroke, and this 1st fuel injection generates the gaseous mixture [Lean / SUTOIKI / (theoretical air fuel ratio) / of whenever / high stratification] 51 to the 2nd alcove 42.

[0033] Subsequently, progress to step S104, fuel injection is made to perform by the low flow rate from the 1st time [near the top dead center] from the second half of a compression stroke, and the rich gaseous mixture 52 near SUTOIKI (theoretical air fuel ratio) is formed in said 1st alcove 41 by this 2nd fuel injection. and it is allotted to the 1st alcove 41 -- rich -- Lean who gaseous mixture 52 is burned behind a top dead center with spark ignition by the ignition plug 11, and is allotted to the 2nd adjoining alcove 42 by generation of heat by this combustion -- gaseous mixture 51 is made to result in compressed self-ignition combustion

[0034] On the other hand, when it was not a low loading field in a compressed self-ignition combustion zone at step S102 and is distinguished, it progresses to step S105 and distinguishes whether it is an inside load field in a compressed self-ignition combustion zone. And when it is an inside load field in a compressed self-ignition combustion zone, it progresses to step S106.

[0035] At step S106, fuel injection is made to perform like an inhalation-of-air line, and this 1st fuel injection generates the gaseous mixture [Lean / SUTOIKI / (theoretical air fuel ratio) / of whenever / high stratification] 51 to the 2nd alcove 42. Subsequently, progress to step S107, fuel injection is made to perform by the low flow rate from the 1st time [near the top dead center] from the second half of a compression stroke, and the rich gaseous mixture 52 near SUTOIKI (theoretical air fuel ratio) is formed in said 1st alcove 41 by this 2nd fuel injection.

[0036] and it is allotted to the 1st alcove 41 -- rich -- Lean who gaseous mixture 52 is burned behind a top dead center with spark ignition by the ignition plug 11, and is allotted to the 2nd adjoining alcove 42 by generation of heat by this combustion -- gaseous mixture 51 is made to result in compressed self-ignition combustion Moreover, when it was not an inside load field at step S105 and is distinguished, it is a heavy load field applicable to a jump-spark-ignition combustion zone, and it progresses to step S108 at this time, and an inhalation-of-air line forms the gaseous mixture of homogeneity in inside from said fuel injection valve 10 at a combustion chamber by carrying out whole-quantity injection of the need fuel quantity at a time.

[0037] And ignition combustion of said uniform gaseous mixture is carried out by jump spark ignition of an ignition plug 11. as mentioned above, rich [near SUTOIKI] in a compressed self-ignition combustion zone -- burning gaseous mixture 52 behind a top dead center by jump spark ignition -- this -- generation of heat of gaseous mixture 52 -- Lean -- if it is the configuration of making gaseous mixture 51 resulting in compressed self-ignition combustion, a great portion of combustion will occur at the period after a top dead center.

[0038] namely, homogeneity -- gaseous mixture -- rich as mentioned above, although self-ignition will be carried out all at once and an ignition stage cannot be delayed, when carrying out compressed self-ignition combustion at a place, and the conditions of a pressure and temperature are ready near a top dead center -- generation of heat by combustion of gaseous mixture 52 -- Lean -- if it is the configuration of making gaseous mixture 51 resulting in compressed self-ignition combustion, the stage of self-ignition can be delayed from a top dead center, and a great portion of combustion will arise at the period after a top dead center.

[0039] As mentioned above, if the period after a top dead center can be made to produce a great portion of combustion, the rate of a pressure buildup in the cylinder leading to knocking is controlled (refer to drawing 4), and a compressed self-ignition field can be expanded to the heavy load side whose demand of fuel quantity increases. Moreover, if whenever [cylinder internal temperature / which influences a compressed self-ignition stage] receives effect in the residual gas in a cylinder and a self-ignition stage carries out a tooth lead angle once, combustion stability will fall, so that whenever [part cylinder internal temperature / whose heat release increases] goes up as shown in drawing 4 , the inclination in which an ignition stage carries out a tooth lead angle more is shown and a self-ignition stage becomes late.

[0040] however, rich [near SUTOIKI] as mentioned above -- burning gaseous mixture 52 by jump spark ignition -- Lean -- if it is the configuration of making gaseous mixture 51 resulting in compressed self-ignition combustion, a self-ignition stage can be controlled through a jump-spark-ignition stage, and is shown in drawing 5 -- as -- the inside of a knocking limitation -- and it becomes possible to control a self-ignition stage within narrow limits which can secure combustion stability.

[0041] By moreover, the thing considered as the configuration which establishes the 1st alcove 41 in the location near the fuel injection valve 10 of a piston crestal plane, is made to adjoin this 1st alcove 41 and forms the 2nd alcove 42 rich -- gaseous mixture 52 -- the 1st alcove 41 -- allotting -- stopping -- Lean -- gaseous mixture 51 is allotted to the 2nd adjoining alcove 42 -- stratification-izing of gaseous mixture -- easy -- it can carry out -- Lean -- the rate of a pressure buildup can be controlled certainly that what is necessary is just to supply the minimum fuel which carries out sufficient generation of heat for making gaseous mixture 51 result in compressed self-ignition combustion to the 1st alcove 41.

[0042] in addition, near SUTOIKI (theoretical air fuel ratio) allotted to said 1st alcove 41 with the above-mentioned operation gestalt is rich -- it is allotted to said 1st alcove 41 although considered as the configuration which carries out jump spark ignition to gaseous mixture 52 -- rich -- Lean who is made to do compressed self-ignition combustion of the gaseous mixture 52, and is allotted to the 2nd alcove 42 by generation of heat by this combustion -- it can also constitute so that gaseous mixture 51 may be made to result in compressed self-ignition combustion.

[0043] Although it becomes possible to be able to delay a great portion of combustion and to control the rate of a pressure buildup by this compared with the case where compressed self-ignition combustion of the uniform gaseous mixture in a combustion chamber 2 is carried out all at once also in the above-mentioned cases it is allotted to said 1st alcove 41 -- rich -- delaying a self-ignition stage more, if it is the configuration to which jump spark ignition of the gaseous mixture 52 is carried out -- possible -- and Lean -- since it is possible to control the self-ignition stage of gaseous mixture 51, the self-ignition combustion stabilized more can be made to perform

[0044] By the way, although it considered as the configuration which makes a fuel inject in 2 steps within the same cycle with the above-mentioned operation gestalt in order to allot the rich gaseous mixture 52 near SUTOIKI (theoretical air fuel ratio) in the 1st alcove 41 and to allot the gaseous mixture [Lean / SUTOIKI] 51 to the 2nd alcove 42, it is possible to also make only one injection in a compression stroke generate gaseous mixture 51 and 52.

[0045] that is, if a fuel is injected in a compression stroke, the fuel spray is collided and spread on the base of the 1st alcove 41, and is rich to the 1st alcove 41 -- the 2nd alcove 42 side which adjoins while gaseous mixture 52 collects -- Lean -- gaseous mixture 51 is generated. however, the direction considered as the configuration which makes a fuel inject in 2 steps -- the gaseous mixture of whenever [high stratification] -- it being stabilized, being able to perform formation and changing the angle of spray of each two injection by to any of the 1st and 2 alcove a fuel is supplied further -- more -- high stratification -- degree gaseous mixture -- formation becomes possible.

[0046] moreover, Lean generated by the 2nd alcove 42 by strengthening the tumble flow (the arrow head A in drawing 1) generated in a cylinder like an inhalation-of-air line as shown in drawing 6 -- diffusion of the fuel which gaseous mixture 51 equalizes and is arranged on the 2nd alcove 42 -- it can control -- Lean -- the combustion stability of gaseous mixture 51 can be raised. So, with this operation gestalt, a suction port 6 is made into a straight port, and the inhalation-of-air line is made into the configuration which is easy to generate a tumble flow in a combustion chamber 2 in inside.
[0047] Moreover, it is made to be held by having formed in the shape of [which uses opening of the 2nd alcove 42 as opening of the shape of a rectangle which spreads to the circumference of a piston crestal plane, and meets a tumble flow in a base] radii in the tumble flow in a combustion chamber 2. Furthermore, the electric shielding valve 61 which covers the abbreviation one half of the side near the cylinder wall of a suction port 6 is infixed, and it is made to have produced channeling of inhalation of air which strengthens a tumble flow with carrying out clausilium of this electric shielding valve 61.
[0048] Lean who will be generated by the 2nd alcove 42 if a tumble flow strengthening means to strengthen a tumble flow positively like the above-mentioned electric shielding valve 61 is formed in a suction port 6 -- diffusion of the fuel which advances equalization of gaseous mixture 51 and is arranged on the 2nd alcove 42 can be controlled more certainly, and the stability of self-ignition combustion can be raised more. In addition, with each above-mentioned operation gestalt, although the configuration of the cylinder head 5 was made into the PENTO roof, it is good also as a configuration [flat, for example], and the configuration of the cylinder head 5 is not limited.

[Translation done.]

* NOTICES *

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] An internal combustion engine's block diagram in an operation gestalt.
[Drawing 2] Drawing showing the self-ignition combustion zone and jump-spark-ignition combustion zone in an operation gestalt.
[Drawing 3] The flow chart which shows the situation of the fuel-injection control in an operation gestalt.
[Drawing 4] The diagram showing correlation with a compressed self-ignition stage, a pressure, and a generating heating value.
[Drawing 5] The diagram showing correlation with a compressed self-ignition stage, knock reinforcement, and combustion stability.
[Drawing 6] The diagram showing correlation with the reinforcement of a tumble flow, and combustion stability.
[Description of Notations]
1 -- Internal combustion engine
2 -- Combustion chamber
3 -- Cylinder
4 -- Piston
4a -- Crestal plane
5 -- Cylinder head
6 -- Suction port
7 -- Intake valve
8 -- Exhaust air port
9 -- Exhaust air bulb
10 -- Fuel injection valve
11 -- Ignition plug
20 -- Engine control unit (ECU)
21 -- Combustion pattern judging section
22 -- Jump-spark-ignition combustion control section
23 -- Self-ignition combustion control section
41 -- The 1st alcove
42 -- The 2nd alcove
51 -- Lean -- gaseous mixture
52 -- rich -- gaseous mixture
61 -- Electric shielding valve

[Translation done.]

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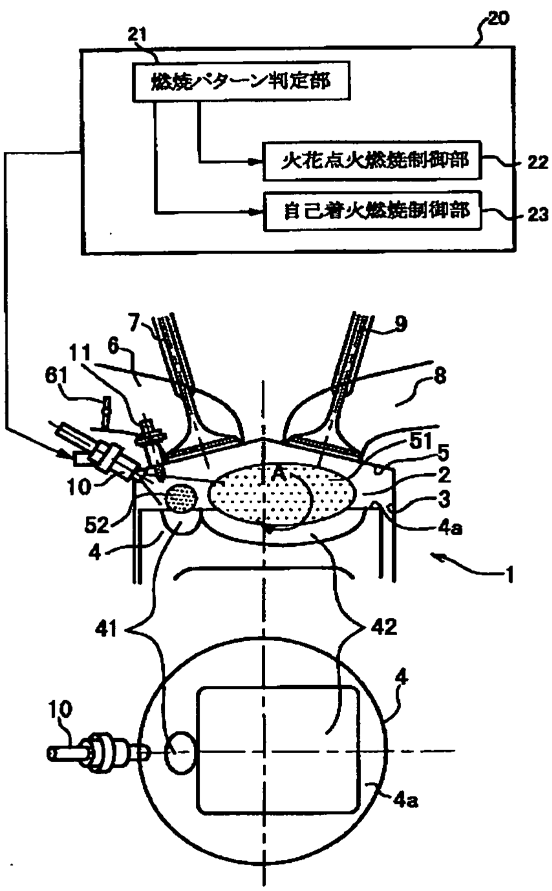
DRAWINGS

[Drawing 1]



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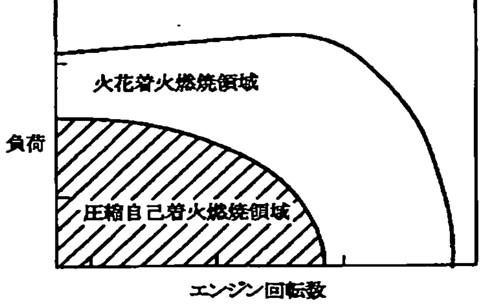
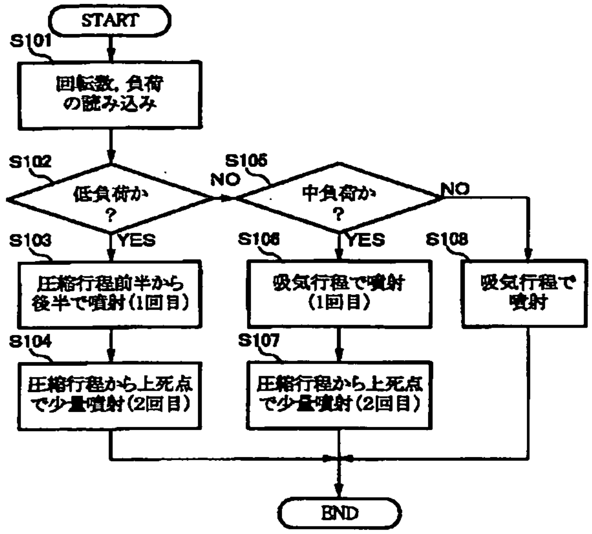


[Drawing 3]



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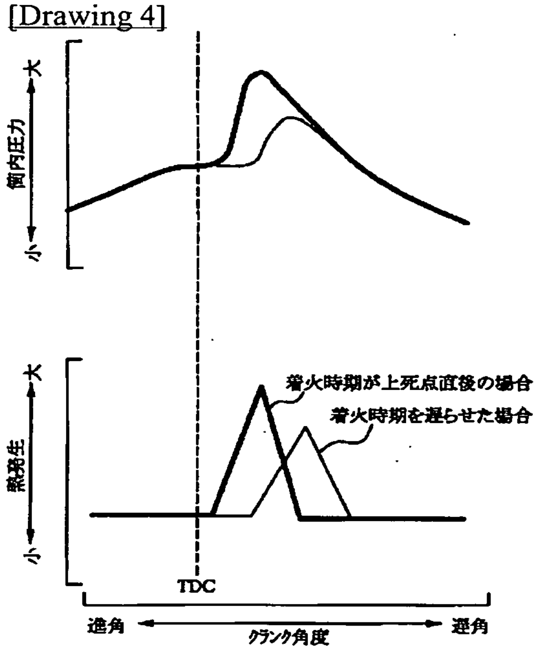

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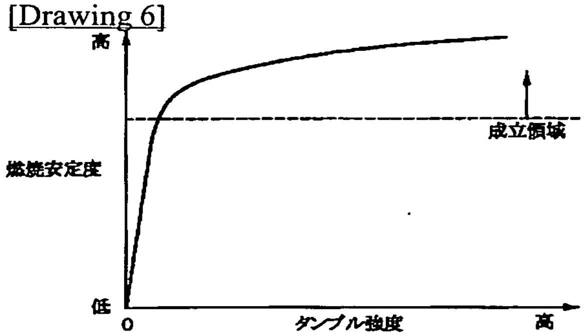
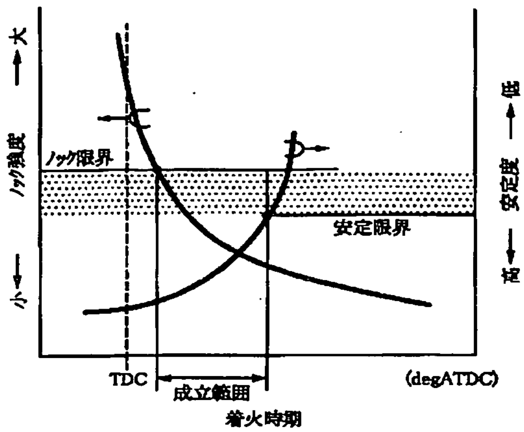


[Drawing 5]



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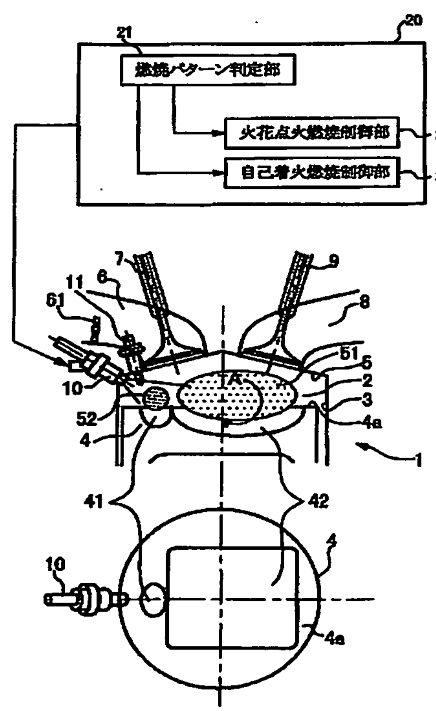
(54)【発明の名称】筒内直接噴射式内燃機関

(57)【要約】
【課題】圧縮自己着火燃焼時に着火時期を遅らせることで、筒内圧の上昇率を抑制し、圧縮自己着火燃焼領域の高負荷側への拡大を可能にする。

【解決手段】吸気ポート６側のシリンダ壁に燃料噴射弁１０を設ける一方、ピストン冠面４ａの燃料噴射弁１０側に開口面積の小さい第１凹室４１を形成し、更に、該第１凹室４１に隣接させて開口面積の大きな第２凹室４２を形成する。そして、前記第１凹室４１にリッチ混合気５２を配し、第２凹室４２にリーン混合気５１を配し、前記リッチ混合気５２を火花点火によって上死点後に燃焼させ、該リッチ混合気５２の燃焼による発熱で、前記リーン混合気５１を圧縮自己着火燃焼に至らしめる。



【特許請求の範囲】

【請求項１】燃焼室の周辺部に燃料噴射弁を備える一方、
ピストン冠面の前記燃料噴射弁側の端部に第１凹室を形成すると共に、
該第１凹室に対して前記燃料噴射弁の軸線方向に隣接する第２凹室を形成したことを特徴とする筒内直接噴射式内燃機関。

【請求項２】前記第１凹室のピストン冠面における開口面積が、前記第２凹室の開口面積よりも小さいことを特徴とする請求項１記載の筒内直接噴射式内燃機関。

【請求項３】前記第１凹室の深さが、前記第２凹室の深さよりも浅いことを特徴とする請求項１又は２記載の筒内直接噴射式内燃機関。

【請求項４】前記第２凹室が、燃料噴射弁の軸線方向における断面で円弧状であって、開口部がピストン冠面の周辺部にまで広がる略長方形状に形成されることを特徴とする請求項１～３のいずれか１つに記載の筒内直接噴射式内燃機関。

【請求項５】吸気ポート内に吸気行程でシリンダ内に形成されるタンブル流を強化するタンブル流強化手段を備えることを特徴とする請求項１～４のいずれか１つに記載の筒内直接噴射式内燃機関。

【請求項６】前記タンブル流強化手段が、吸気ポートを部分的に開閉する遮断弁であり、該遮断弁を閉じることで吸気に偏流を生じさせ、吸気行程でシリンダ内に形成されるタンブル流を強化することを特徴とする請求項５記載の筒内直接噴射式内燃機関。

【請求項７】前記第１凹室にリッチな混合気を配し、前記第２凹室にリーンな混合気を配することを特徴とする請求項１～６のいずれか１つに記載の筒内直接噴射式内燃機関。

【請求項８】前記第１凹室に配したリッチな混合気が上死点近傍において圧縮自己着火に至る混合気であり、該第１凹室に配したリッチな混合気の圧縮自己着火により、前記第２凹室に配したリーンな混合気を圧縮自己着火燃焼に至らしめることを特徴とする請求項７記載の筒内直接噴射式内燃機関。

【請求項９】前記第１凹室に配したリッチな混合気を点火プラグの火花点火によって着火させることにより、前記第２凹室に配したリーンな混合気を圧縮自己着火燃焼に至らしめることを特徴とする請求項７記載の筒内直接噴射式内燃機関。

【請求項１０】圧縮行程中に前記燃料噴射弁から燃料を噴射させることにより、前記第１凹室にリッチな混合気を配し、前記第２凹室にリーンな混合気を配することを特徴とする請求項７～９のいずれか１つに記載の筒内直接噴射式内燃機関。

【請求項１１】同一サイクル内において、圧縮行程後半から上死点近傍における燃料噴射と、該噴射時期よりも前の燃料噴射との少なくとも２回に分けて燃料を噴射させることで、前記第１凹室にリッチな混合気を配し、前記第２凹室にリーンな混合気を配することことを特徴とする請求項７～９のいずれか１つに記載の筒内直接噴射式内燃機関。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、筒内直接噴射式内燃機関に関し、特に、ガソリンのようなセタン価の低い燃料を用いて圧縮自己着火燃焼を行わせる機関に関する。

【０００２】

【従来の技術】従来、圧縮自己着火燃焼を行う内燃機関として、特開平１０－１９６４２４号公報に開示されるものがあった。このものは、シリンダ内のピストンとは別に、補助圧縮手段としてコントロールピストンを備え、自己着火寸前の高温にまで圧縮された混合気に対し、前記コントロールピストンによる圧縮をさらに加えることで、上記混合気を一斉に自己着火させる構成となっている。

【０００３】また、点火プラグによる火花点火により自己着火を引き起こすよう構成された機関が、特開平１１－２１０５３９号公報に開示されている。このものは、圧縮行程末期におけるシリンダ内のガス温度が、点火すると混合気全体の自己着火を引き起こす目標温度であるか否かを判断し、この判断に基づいて吸気弁の開弁時期を制御することにより、圧縮行程末期におけるシリンダ内のガス温度を上記目標温度に維持するようにしている。

【０００４】

【発明が解決しようとする課題】ところで、圧縮自己着火燃焼は、火炎伝播による燃焼と異なり、局所的な燃焼温度が低く、ＮＯｘが極微量にしか発生しないという利点があるが、その反面、均質な混合気場においては、シリンダ内全域が一斉に着火するため、負荷の上昇に伴って混合気をリッチ化すると、シリンダ内の圧力上昇率が大きくなりすぎ、振動・騒音が大きくなるという問題がある。

【０００５】従って、圧縮自己着火燃焼運転を行わせる負荷領域を高負荷側に拡大するためには、着火時期を上死点付近又はそれ以降に設定し、大部分の燃焼を上死点より後の期間に生じさせることで、シリンダ内の圧力上昇率を抑制する必要がある。しかしながら、着火時期を上死点付近又はそれ以降に遅らせた場合には、ピストンの下降と共に初期の燃焼が進むことになるため、燃焼が不安定になり易く、圧縮自己着火燃焼運転を行わせる負荷領域を高負荷側に拡大するためには、着火の時期を遅らせ、かつ、安定した燃焼性が得られるようにする必要がある。

【０００６】一方、均質な混合気場において、特開平１

１－２１０５３９号公報に開示されるような点火プラグによるアシストを適用すれば、圧縮自己着火燃焼の着火時期を安定させせることができる。しかし、上記の方法では、上死点付近又はそれ以降に圧縮自己着火燃焼が発生するとしても、着火時期を遅らせることができず、圧縮自己着火燃焼領域の高負荷側への拡大には効果を発揮しない。

【０００７】また、圧縮自己着火燃焼において、局所的にリッチな混合気場を形成し、そこから自己着火或いは火花着火させ、リッチな混合気場からの燃焼により周囲の燃料を圧縮自己着火させる方法が特開平１１－２１０５３９号公報に開示されている。しかし、特開平１１－２１０５３９号公報に開示されるように、燃焼室の吸気弁が配置される側の周壁からピストン冠面に向け燃料を噴射し、ピストン冠面に設けられた壁面に沿って燃料噴霧を持ち上げて点火プラグ周りに集める構成では、リッチ混合気を一定の場所に留めておくことが困難であって、シリンダヘッド中心に配した点火プラグへリッチな混合気を安定供給するためには、多くの燃料を噴射する必要があり、上死点付近もしくはそれ以降に着火時期を遅らせることができたとしても、リッチな混合気が多く存在するため、圧力上昇率を下げることは困難である。

【０００８】本発明は上記問題点に鑑みなされたものであり、リッチな混合気場からの燃焼により周囲の燃料を圧縮自己着火させることで、確実に圧力上昇率を抑制することができ、以って、圧縮自己着火燃焼領域を高負荷側に拡大することが可能となる筒内直接噴射式内燃機関を提供することを目的とする。

【０００９】

【課題を解決するための手段】そのため、請求項１記載の発明では、燃焼室の周辺部に燃料噴射弁を備える一方、ピストン冠面の前記燃料噴射弁側の端部に第１凹室を形成すると共に、該第１凹室に対して前記燃料噴射弁の軸線方向に隣接する第２凹室を形成する構成とした。

【００１０】かかる構成によると、燃料噴射弁の軸線方向に沿って、ピストン冠面上に第１凹室及び第２凹室が形成され、これら第１凹室及び第２凹室にそれぞれ異なる濃度（空燃比）の混合気を形成することが可能となる。請求項２記載の発明では、前記第１凹室のピストン冠面における開口面積を、前記第２凹室の開口面積よりも小さくする構成とした。

【００１１】かかる構成によると、燃料噴射弁に近い側の第１凹室の開口面積が、燃料噴射弁から遠い側の第２凹室の開口面積よりも狭く、第１凹室によって局所的な混合気場が形成される一方、濃度の異なる混合気を開口面積の広い第２凹室に配することで、燃焼室内で濃度の異なる混合気の成層化が行われる。請求項３記載の発明では、前記第１凹室の深さを、前記第２凹室の深さよりも浅くする構成とした。

【００１２】かかる構成によると、燃料噴射弁に近い側の第１凹室の深さが、燃料噴射弁から遠い側の第２凹室の開口面積よりも浅く、第１凹室によって局所的な混合気場が形成される一方、濃度の異なる混合気を深い第２凹室に配することで、燃焼室内で濃度の異なる混合気の成層化が行われる。請求項４記載の発明では、前記第２凹室が、燃料噴射弁の軸線方向における断面で円弧状であって、開口部がピストン冠面の周辺部にまで広がる略長方形状に形成される構成とした。

【００１３】かかる構成によると、第２凹室の底面が、燃料噴射弁の軸線方向における断面で円弧状であって、然も、ピストン冠面の周辺部にまで広がる略長方形状に形成されることで、シリンダ内の吸気によるタンブル流が保持される。請求項５記載の発明では、吸気ポート内に吸気行程でシリンダ内に形成されるタンブル流を強化するタンブル流強化手段を備える構成とした。

【００１４】かかる構成によると、タンブル流強化手段によってシリンダ内に吸気によって形成されるタンブル流を積極的に強化する。請求項６記載の発明では、前記タンブル流強化手段が、吸気ポートを部分的に開閉する遮断弁であり、該遮断弁を閉じることで吸気に偏流を生じさせ、吸気行程でシリンダ内に形成されるタンブル流を強化する構成とした。

【００１５】かかる構成によると、吸気ポートの一部が遮断弁によって遮蔽されることで、タンブル流を強化するように吸気の偏流が生じる。請求項７記載の発明では、前記第１凹室にリッチな混合気を配し、前記第２凹室にリーンな混合気を配する構成とした。かかる構成によると、第１凹室にリッチな混合気が配される一方、この第１凹室に隣接する第２凹室にリーンな混合気が配され、リッチ混合気が火花点火或いは圧縮自己着火によって燃焼することで、隣接するリーンな混合気をリッチ混合気の発熱で自己着火燃焼に至らしめることが可能である。

【００１６】請求項８記載の発明では、前記第１凹室に配したリッチな混合気が上死点近傍において圧縮自己着火に至る混合気であり、該第１凹室に配したリッチな混合気の圧縮自己着火により、前記第２凹室に配したリーンな混合気を圧縮自己着火燃焼に至らしめる構成とした。かかる構成によると、第１凹室に配したリッチな混合気が圧縮自己着火に至ると、その発熱によって隣接する第２凹室に配したリーンな混合気が圧縮自己着火燃焼に至る。

【００１７】請求項９記載の発明では、前記第１凹室に配したリッチな混合気を点火プラグの火花点火によって着火させることにより、前記第２凹室に配したリーンな混合気を圧縮自己着火燃焼に至らしめる構成とした。かかる構成によると、第１凹室に配したリッチな混合気が点火プラグによって火花点火されると、その発熱によって隣接する第２凹室に配したリーンな混合気が圧縮自己着火燃焼に至る。

【００１８】請求項１０記載の発明では、圧縮行程中に前記燃料噴射弁から燃料を噴射させることにより、前記第１凹室にリッチな混合気を配し、前記第２凹室にリーンな混合気を配する構成とした。かかる構成によると、圧縮行程中に燃料を噴射することで、燃料噴霧が第１凹室の底面に衝突拡散し、第１凹室にはリッチな混合気が溜まり、また、隣接する第２凹室にリーンな混合気が形成される。

【００１９】請求項１１記載の発明では、同一サイクル内において、圧縮行程後半から上死点近傍における燃料噴射と、該噴射時期よりも前の燃料噴射との少なくとも２回に分けて燃料を噴射させることで、前記第１凹室にリッチな混合気を配し、前記第２凹室にリーンな混合気を配する構成とした。かかる構成によると、圧縮行程後半から上死点近傍において噴射される燃料は、第１凹室内の留まってリッチ混合気を形成する一方、該圧縮行程後半から上死点近傍における噴射時期よりも前の時期において噴射された燃料は、拡散によって第２凹室にリーン混合気を形成する。

【００２０】

【発明の効果】請求項１記載の発明によると、第１凹室と第２凹室とに異なる濃度（空燃比）の混合気を配し、混合気を安定的に成層化することが可能で、リッチな混合気場からの燃焼により隣接するリーンな混合気を圧縮自己着火させる構成において、リッチな混合気を必要最小限だけ生成させて着火させることができ、大部分の燃料の燃焼を遅らせることができるようになるという効果がある。

【００２１】請求項２，３記載の発明によると、第１凹室を局所的な混合気形成場として、濃度の異なる混合気を確実に成層化することができるという効果がある。請求項４記載の発明によると、第２凹室により吸気によるタンブル流が保持され、第２凹室に生成される混合気を均一化することができ、燃焼安定性を向上させることができるという効果がある。

【００２２】請求項５，６記載の発明によると、吸気により生成されるタンブル流を強化することで、第２凹室に生成される混合気を均一化することができ、燃焼安定性を向上させることができるという効果がある。請求項７記載の発明によると、第１凹室に安定的に配される局所的なリッチ混合気の燃焼により、第２凹室に配されるリーンな混合気を圧縮自己着火させることができ、必要最小限のリッチ混合気の燃焼で、大部分の燃料を圧縮自己着火燃焼に至らしめることが可能となり、大部分の燃料の燃焼が遅れることで圧縮自己着火燃焼領域を高負荷側に拡大することができるようになるという効果がある。

【００２３】請求項８記載の発明によると、第１凹室に配されるリッチな混合気の圧縮自己着火燃焼により隣接する第２凹室に配されるリーンな混合気を圧縮自己着火燃焼に至らしめるので、大部分の燃焼を上死点付近もしくはそれ以降に発生させ、圧力上昇率を抑制することができ、圧縮自己着火燃焼領域を高負荷側に拡大することができるようになるという効果がある。

【００２４】請求項９記載の発明によると、第１凹室に配されるリッチな混合気の火花点火燃焼により隣接する第２凹室に配されるリーンな混合気を圧縮自己着火燃焼に至らしめるので、大部分の燃焼を上死点付近もしくはそれ以降に発生させ、圧力上昇率を抑制することができ、圧縮自己着火燃焼領域を高負荷側に拡大することができると共に、第１凹室に配されるリッチな混合気を火花点火燃焼させるので、自己着火時期を、圧力上昇率を抑制できかつ燃焼安定度を確保できる範囲内に制御することができるという効果がある。

【００２５】請求項１０記載の発明によると、圧縮行程中の噴射によって、第１凹室にリッチな混合気を配し、第２凹室にリーンな混合気を配することが容易に行えるという効果がある。請求項１１記載の発明によると、同一サイクル内で２回以上に分けて燃料を噴射する構成とし、かつ、圧縮行程後半から上死点近傍において２回目以降の燃料噴射を行わせることで、第１凹室に安定的にリッチ混合気を形成することができるという効果がある。

【００２６】

【発明の実施の形態】以下に本発明の実施の形態を図に基づいて説明する。図１は、本発明が適用される筒内直接噴射式のガソリン機関を示す。この図１において、機関１の燃焼室２は、シリンダ３，ピストン４，シリンダヘッド５によって形成される。

【００２７】前記燃焼室２に連通する吸気ポート６には吸気バルブ７が介装され、同じく燃焼室２に連通する排気ポート８には排気バルブ９が介装される。前記シリンダヘッド５はペントルーフ型に形成され、前記吸気バルブ７及び排気バルブ９はV型に配置される。前記吸気ポート６側のシリンダ壁には、ピストン冠面４ａに向けて燃料を噴射する燃料噴射弁１０が設けられ、該燃料噴射弁１０近傍のシリンダヘッド５には、燃料噴射弁１０直下の混合気を火花点火すべく点火プラグ１１が設けられる。

【００２８】前記ピストン４の冠面には、第１凹室４１及び第２凹室４２が形成される。前記第１凹室４１は、ピストン冠面の燃料噴射弁１０側の端部に形成されるものであり、開口部を燃料噴射弁１０の軸方向に短い楕円形とすると共に、底面が中心ほど深くなるように形成される。尚、前記第１凹室４１の開口面積は、点火プラグ１１近傍に局所的な混合気場を形成すべく、第２凹室４２の開口面積に比べて大幅に小さく形成される。

【００２９】また、第２凹室４２は、前記第１凹室４１に対して燃料噴射弁１０の軸線方向に隣接して形成されるものであり、燃料噴射弁１０に近い側から第１凹室４

１，第２凹室４２の順で並んで形成される。前記第２凹室４２の開口部は、燃料噴射弁１０の軸線方向に沿って延びる一対の辺とこれらの辺に直交する一対の辺からなる長方形状であって、ピストン冠面の周辺部にまで広がるように形成される。そして、前記長方形状の開口部の燃料噴射弁１０側の１辺に、前記第１凹室４１の楕円形状の開口部が接するようにして、第１凹室４１と第２凹室４２とが隣接する。

【００３０】また、前記第２凹室４２の底面は、燃料噴射弁１０の軸線方向の断面で円弧状になるように形成され、最大深さは、前記第１凹室４１よりも深くなるように形成される。前記燃料噴射弁１０による噴射量・噴射時期及び点火プラグ１１による点火時期を制御するエンジンコントロールユニット（以下、ＥＣＵという）２０は、圧縮自己着火燃焼と火花点火燃焼とのいずれの燃焼方式で運転を行うかを運転条件に応じて判定する燃焼パターン判定部２１、火花点火燃焼時に前記燃料噴射弁１０及び点火プラグ１１を制御する火花点火燃焼制御部２２、圧縮自己着火燃焼時に前記燃料噴射弁１０及び点火プラグ１１を制御する自己着火燃焼制御部２３によって構成される。

【００３１】前記燃焼パターン判定部２１は、図２に示すように、機関の負荷と回転数Ｎ（rpm）に基づいて燃焼方式を判別する構成であり、低中負荷・低中回転領域を圧縮自己着火燃焼領域として判定し、それ以外の高負荷・高回転領域を火花点火燃焼領域と判定する。尚、前記燃焼パターン判定部２１，火花点火燃焼制御部２２及び自己着火燃焼制御部２３は、ハードワイヤードの論理回路で構成することが可能であるが、本実施形態では、マイクロコンピュータのプログラムとして実現される。

【００３２】図３のフローチャートは、前記ＥＣＵ２０による燃料噴射制御の様子を示すものであり、ステップＳ１０１では、機関１の負荷及び回転数を読み込む。ステップＳ１０２では、図２に示す圧縮自己着火燃焼領域内の低負荷領域であるか否かを判別する。そして、圧縮自己着火燃焼領域内の低負荷領域であるときには、ステップＳ１０３へ進み、圧縮行程前半から後半で燃料噴射を行わせ、この１回目の燃料噴射によって、第２凹室４２に高成層度のストイキ（理論空燃比）よりもリーンな混合気５１を生成する。

【００３３】次いで、ステップＳ１０４へ進み、圧縮行程後半から上死点近傍において、１度目よりも低流量で燃料噴射を行わせ、この２回目の燃料噴射によって前記第１凹室４１にストイキ（理論空燃比）付近のリッチな混合気５２を形成する。そして、第１凹室４１に配されるリッチ混合気５２を、点火プラグ１１による火花着火により上死点後に燃焼させ、該燃焼による発熱で、隣接する第２凹室４２に配されるリーン混合気５１を圧縮自己着火燃焼に至らしめる。

【００３４】一方、ステップＳ１０２で圧縮自己着火燃焼領域内の低負荷領域ではないと判別されたときには、ステップＳ１０５へ進み、圧縮自己着火燃焼領域内の中負荷領域であるか否かを判別する。そして、圧縮自己着火燃焼領域内の中負荷領域であるときには、ステップＳ１０６へ進む。

【００３５】ステップＳ１０６では、吸気行程で燃料噴射を行わせ、この１回目の燃料噴射によって、第２凹室４２に高成層度のストイキ（理論空燃比）よりもリーンな混合気５１を生成する。次いで、ステップＳ１０７へ進み、圧縮行程後半から上死点近傍において、１度目よりも低流量で燃料噴射を行わせ、この２回目の燃料噴射によって前記第１凹室４１にストイキ（理論空燃比）付近のリッチな混合気５２を形成する。

【００３６】そして、第１凹室４１に配されるリッチ混合気５２を点火プラグ１１による火花着火により上死点後に燃焼させ、該燃焼による発熱で、隣接する第２凹室４２に配されるリーン混合気５１を圧縮自己着火燃焼に至らしめる。また、ステップＳ１０５で中負荷領域でないと判別されたときには、火花点火燃焼領域に該当する高負荷領域であり、このときには、ステップＳ１０８へ進み、吸気行程中に前記燃料噴射弁１０から必要燃料量を１度に全量噴射することで、燃焼室内に均一の混合気を形成する。

【００３７】そして、点火プラグ１１の火花点火により前記均一な混合気を着火燃焼させる。上記のように、圧縮自己着火燃焼領域では、ストイキ近傍のリッチ混合気５２を火花点火によって上死点後に燃焼させることにより、該混合気５２の発熱によってリーン混合気５１を圧縮自己着火燃焼に至らしめる構成であれば、大部分の燃焼が上死点よりも後の期間に発生することになる。

【００３８】即ち、均一混合気場で圧縮自己着火燃焼させる場合には、上死点付近で圧力及び温度の条件が整ったときに一斉に自己着火することになり、着火時期を遅らせることができないが、上記のように、リッチ混合気５２の燃焼による発熱で、リーン混合気５１を圧縮自己着火燃焼に至らしめる構成であれば、上死点から自己着火の時期を遅らせることができ、大部分の燃焼が上死点より後の期間に生じることになる。

【００３９】上記のように、大部分の燃焼を上死点より後の期間に生じさせることができれば、ノッキングの原因となるシリンダ内の圧力上昇率が抑制され（図４参照）、圧縮自己着火領域を燃料量の要求が増える高負荷側に拡大することができる。また、圧縮自己着火時期を左右するシリンダ内温度は、シリンダ内の残留ガスに影響を受け、１度自己着火時期が進角すると、図４に示すように熱発生が多くなる分シリンダ内温度が上昇し、着火時期がより進角する傾向を示し、また、自己着火時期が遅くなるほど燃焼安定度が低下する。

【００４０】しかし、上記のように、ストイキ近傍のリッチ混合気５２を火花点火によって燃焼させることによ

り、リーン混合気５１を圧縮自己着火燃焼に至らしめる構成であれば、自己着火時期を、火花点火時期を介して制御でき、図５に示すように、ノッキング限界内でかつ燃焼安定度を確保できる狭い範囲内に、自己着火時期を制御することが可能となる。

【００４１】また、ピストン冠面の燃料噴射弁１０に近い位置に第１凹室４１を設け、該第１凹室４１に隣接させて第２凹室４２を設ける構成としたことで、リッチ混合気５２を第１凹室４１に配して留めておき、リーン混合気５１を隣接する第２凹室４２に配する、混合気の成層化が容易に行え、リーン混合気５１を圧縮自己着火燃焼に至らしめるのに充分な発熱をする最低限の燃料を第１凹室４１に供給すれば良く、圧力上昇率を確実に抑制することができる。

【００４２】尚、上記実施形態では、前記第１凹室４１に配されるストイキ（理論空燃比）付近のリッチ混合気５２に火花点火する構成としたが、前記第１凹室４１に配されるリッチ混合気５２を圧縮自己着火燃焼させ、該燃焼による発熱で第２凹室４２に配されるリーン混合気５１を圧縮自己着火燃焼に至らしめるよう構成することもできる。

【００４３】上記の場合も、燃焼室２内の均一な混合気を一斉に圧縮自己着火燃焼させる場合に比べて、大部分の燃焼を遅らせることができ、これによって、圧力上昇率を抑制することが可能となるが、前記第１凹室４１に配されるリッチ混合気５２を火花点火させる構成であれば、より自己着火時期を遅らせることが可能で、かつ、リーン混合気５１の自己着火時期を制御することが可能であるので、より安定した自己着火燃焼を行わせることができる。

【００４４】ところで、上記実施形態では、第１凹室４１にストイキ（理論空燃比）付近のリッチな混合気５２に配し、第２凹室４２にストイキよりもリーンな混合気５１を配するために、同一サイクル内で２回に分けて燃料を噴射させる構成としたが、圧縮行程中の１回の噴射のみによって、混合気５１，５２の生成を行わせることも可能である。

【００４５】即ち、圧縮行程中に燃料を噴射すれば、燃料噴霧が第１凹室４１の底面に衝突して拡散し、第１凹室４１にリッチ混合気５２が溜まる一方、隣接する第２凹室４２側にはリーン混合気５１が生成される。但し、２回に分けて燃料を噴射させる構成とした方が、高成層度の混合気形成が安定して行え、更に、２回の噴射それぞれの噴霧角を第１，２凹室のいずれに燃料を供給するかによって異ならせることで、より高成層度な混合気形成が可能となる。

【００４６】また、図６に示すように、吸気行程でシリンダ内に生成されるタンブル流（図１中の矢印Ａ）を強化することで、第２凹室４２に生成されるリーン混合気５１が均一化して、かつ、第２凹室４２に配する燃料の拡散を抑制でき、リーン混合気５１の燃焼安定度を向上させることができる。そこで、本実施形態では、吸気ポート６をストレートポートとし、吸気行程中に燃焼室２内でタンブル流を発生し易い形状としてある。

【００４７】また、第２凹室４２の開口部を、ピストン冠面の周辺まで広がる長方形状の開口とし、かつ、底面をタンブル流に沿うような円弧状に形成したことで、燃焼室２内のタンブル流が保持されるようにしてある。更に、吸気ポート６のシリンダ壁に近い側の略半分を遮蔽する遮蔽弁６１を介装し、該遮蔽弁６１を閉弁させることで、タンブル流を強化するような吸気の偏流を生じさせるようにしてある。

【００４８】上記の遮蔽弁６１のようにタンブル流を積極的に強化するタンブル流強化手段を吸気ポート６に設ければ、第２凹室４２に生成されるリーン混合気５１の均一化を進め、また、第２凹室４２に配する燃料の拡散をより確実に抑制でき、自己着火燃焼の安定度をより向上させることができる。尚、上記各実施形態では、シリンダヘッド５の形状をペントルーフとしたが、例えばフラットな形状としても良く、シリンダヘッド５の形状を限定するものではない。

【図面の簡単な説明】

【図１】実施形態における内燃機関の構成図。

【図２】実施形態における自己着火燃焼領域と火花点火燃焼領域とを示す図。

【図３】実施形態における燃料噴射制御の様子を示すフローチャート。

【図４】圧縮自己着火時期と圧力及び発生熱量との相関を示す線図。

【図５】圧縮自己着火時期とノック強度及び燃焼安定度との相関を示す線図。

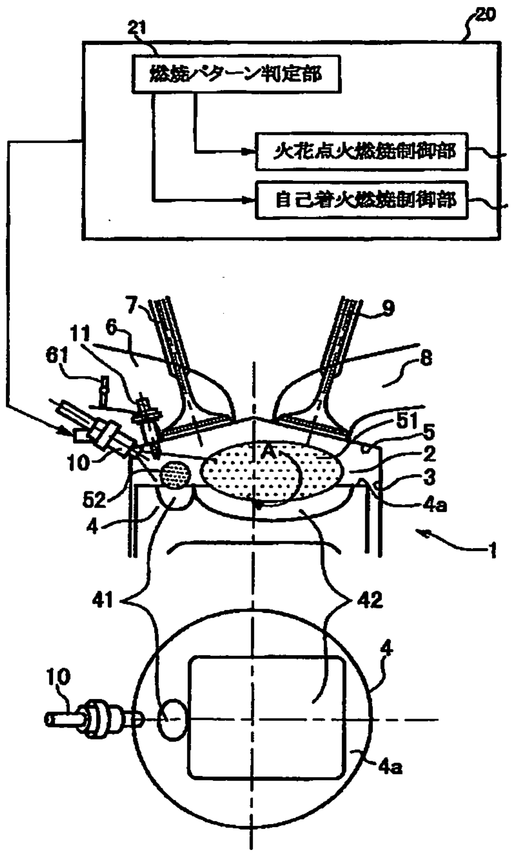
【図６】タンブル流の強度と燃焼安定度との相関を示す線図。

【符号の説明】

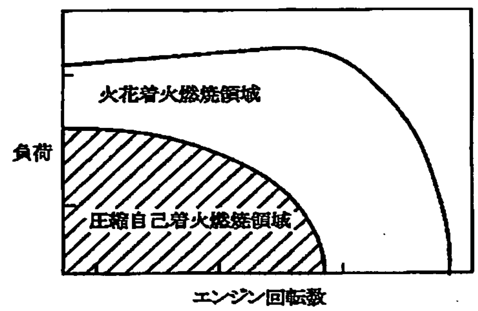
１…内燃機関
２…燃焼室
３…シリンダ
４…ピストン
４ａ…冠面
５…シリンダヘッド
６…吸気ポート
７…吸気バルブ
８…排気ポート
９…排気バルブ
１０…燃料噴射弁
１１…点火プラグ
２０…エンジンコントロールユニット（ＥＣＵ）
２１…燃焼パターン判定部
２２…火花点火燃焼制御部
２３…自己着火燃焼制御部

４１…第１凹室
４２…第２凹室
５１…リーン混合気
５２…リッチ混合気
６１…遮蔽弁

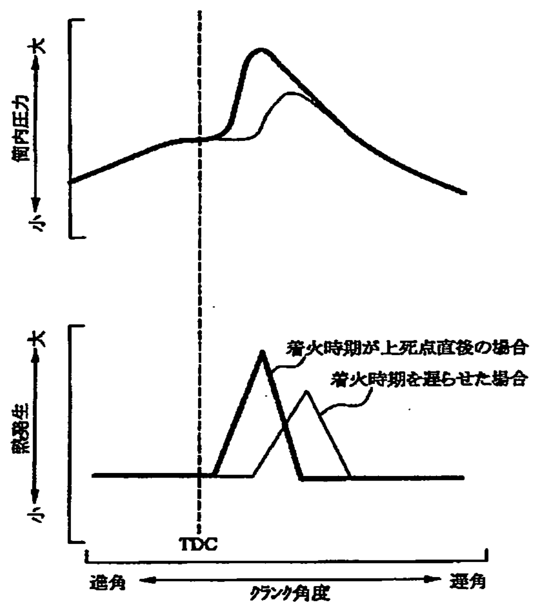
【図１】



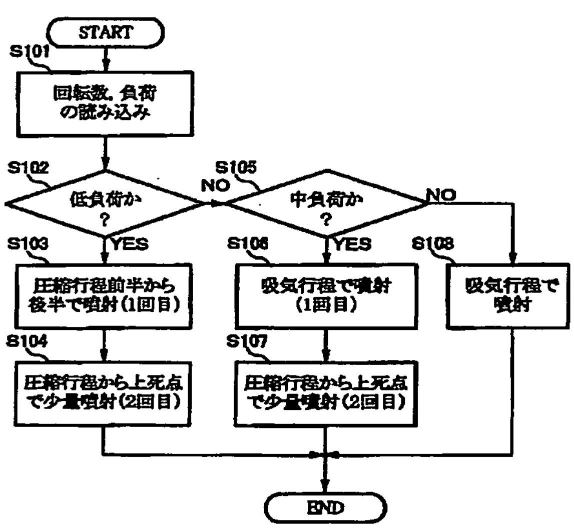
【図２】



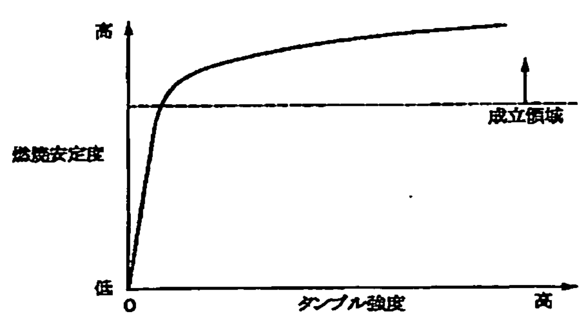
【図４】



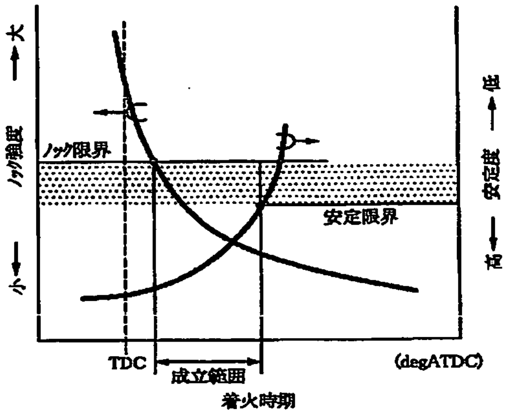
【図３】



【図６】



【図５】



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	41/38			41/38	Ｂ
	41/40			41/40	Ｄ
Ｆ０２Ｆ	3/26		Ｆ０２Ｆ	3/26	Ｃ
					Ｂ